Improving CPUE standardisation for Iberian hake: modelling approaches using reference fleet and Tweedie distribution

Andreia V. Silva, Hugo Mendes, Cristina Silva

Instituto Português do Mar e da Atmosfera, I.P.

Avenida Dr. Alfredo Magalhães Ramalho, 6 1495-165 Lisboa, Portugal

INTRODUCTION

The total Portuguese landings of *Merluccius merluccius* represent about 21% of Southern Hake stock landings. The current Portuguese trawlers standardized landing per unit of effort (LPUE) uses a generalized linear model (GLM) with Gamma distribution and log link and excludes the null observations, which represent about 69% of the total data set. This methodology uses the predictions from a "reference fleet" on the standardized model to estimate the LPUE (Cardador & Jardim, 2010). In fact, this "reference fleet" combines specific reference levels from the different factors of the GLM model. Recent advances in modelling techniques have enabled the possibility of applying more complex models and statistical distributions that allows for frequent zero valued observations which are common in commercial catches from logbook data.

AIM: i) Model the Portuguese hake trawl CPUE using the Tweedie distribution to handle zero-catch data, ii) compare the results of the two methods of standardizing LPUEs and the CPUE from the Portuguese Autumn groundfish surveys (IBTS).

METHODS

- The historical catch and effort data from the trawlers in Portuguese coast (Figure 1) were compiled and analyzed from both paper (1989-2018) and e-logbooks (2012-2020).
- Variables included in the model: year, métier (according to Silva *et al.*,2009), zone, trawl duration (hours; h), total catch per haul (catch; kg), the proportion of Hake in the total catch (p_hke), vessel engine power (power; kw) , length over all (loa; m) and vessel gross tonnage (ton_gt; ton) (see table 1).
- LPUE was standardized with a GLM using a Tweedie distribution to handle the high proportion of zeros. Model fitting and selection follow the methodology described in Coelho *et al.*,2021.
- The estimated standardized LPUE index was compared with the LPUE from the reference fleet and the CPUE from the Portuguese IBTS survey, using graphical analysis and Pearson correlation.

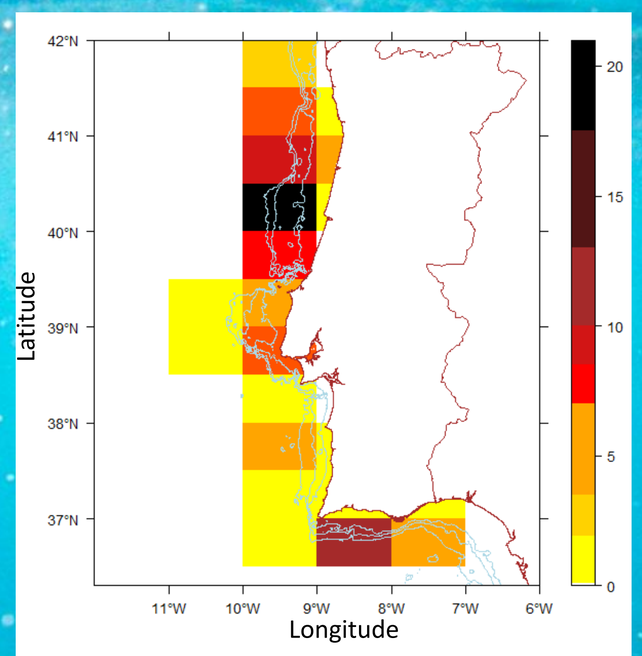


Figure 1. Spatial distribution of the fishing effort of Iberian hake (logbook data from 1989 to 2020)

RESULTS AND DISCUSSION

Table 1. Summary of GLM results: explained deviance of covariates, AIC and explained deviance of the models . * variable transformed with fractional polynomials. ** Model diagnostics of the residuals patterns (QQ-plot; Fitted vs observed; residuals variables): ✓ – normal residuals ; ✘ – non normal residuals; nc – model not comparable. Shaded grey - Model selected

	yearc	month	zone	metier	hours*	cat_ hours	catch*	cat_ catch	p_hke*	cat_ phke	power*	cat_ power*	loa	ton_gt	AIC	Explained deviance (%)	Model diagnostics**
Mod_C&J	15.2%		9.11	2.5		11		20.2		8.28		1.18			531059	67	nc; ✓
Mod1	6.0%	0.5%	1.0%	5.4%		2.6%		24.0%		24.1%		0.4%			1615657	63.9	✓
Mod2	6.0%	0.5%	0.5%	5.8%	6.2%		12.7%		56.1%		4.1%		0.9	0.2%	-	-	✘
Mod3	6.0%	0.5%	0.5%	5.8%	3.7%		24.3%			24.4%	0.1%		0.1%	0.0%	1603876	65.4	✓
Mod4	6.0%	0.5%	0.5%	5.8%	3.7%		24.3%			24.4%	0.1%				1604999	65.2	✓
Mod5	6.0%	0.5%	0.5%	5.8%	3.1%			24.3%		24.4%		0.8%			1604043	65.3	✓
Mod6	**6.0%**			**5.8%**	**3.3%**			**24.6%**		**24.8%**		**0.6%**			**1605655**	**65.1**	✓
Mod7	6.0%			5.8%		1.7%		24.6%		24.8%		0.6%			1618798	63.5	✓
Mod8	6.0%			5.8%	6.2%			22.3%		24.9%					1606798	65.0	✓

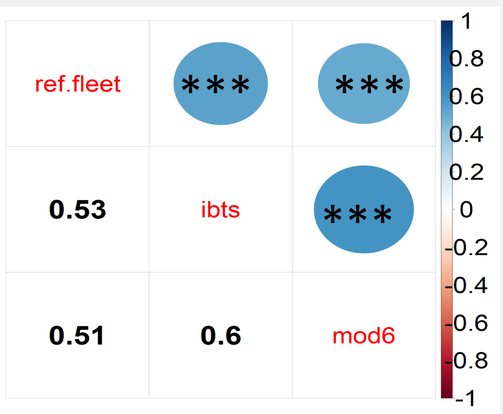


Figure 3. Pearson correlation between CPUEs from reference fleet (ref.fleet), botton trawl survey (ibts) and model 6. * significant level (p<0.01)**

- The selected model (Model 6) was obtained with *hours* as a continuous variable and the categorized variables *year*, *metier*, *catch*, *p_hke* and *power* (Table 1).
- Model 6 is represented as:

  HKE*cpue ~ year + metier+ cat_catch + cat_phke + cat_power+ f(hours)*
- Despite vessel power explaining only 0.6% of the model deviance, the AIC value increases when this variable is removed.
- The annual standardized LPUE/CPUE trends are similar (Figure 2). The IBTS CPUE had higher correlation with Model 6 (Figure 3).

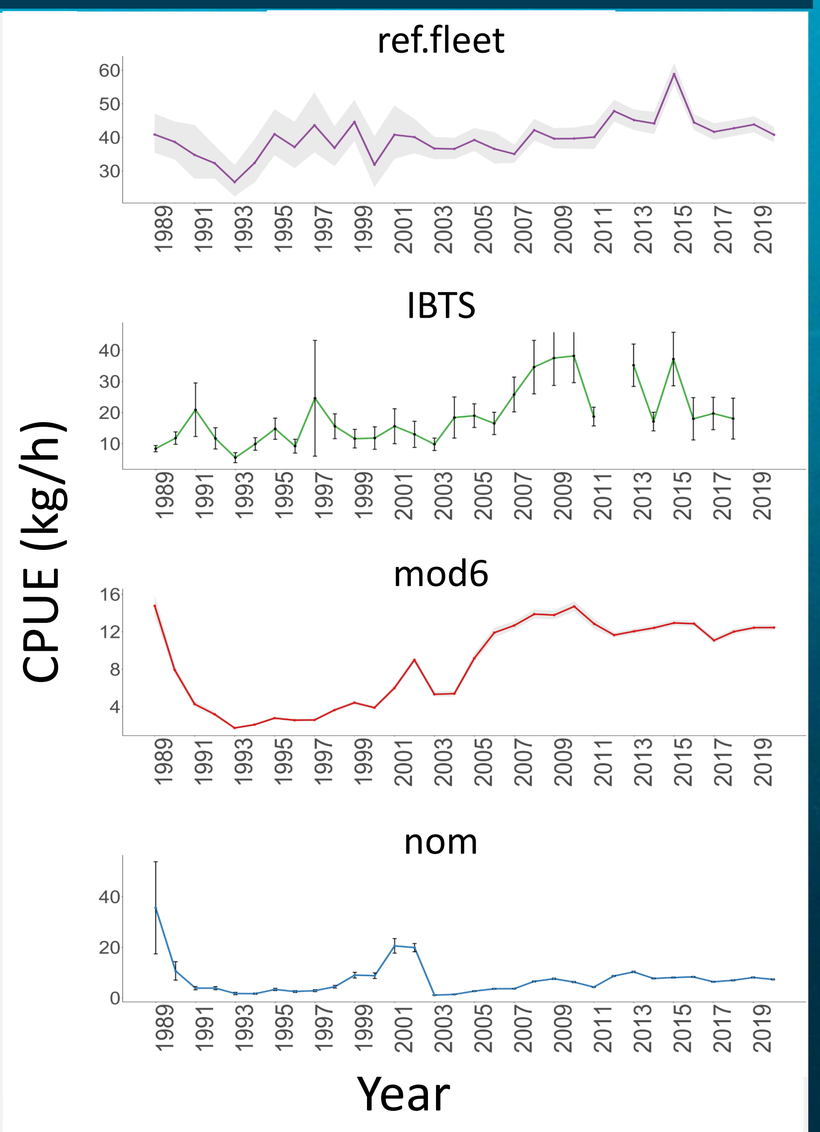
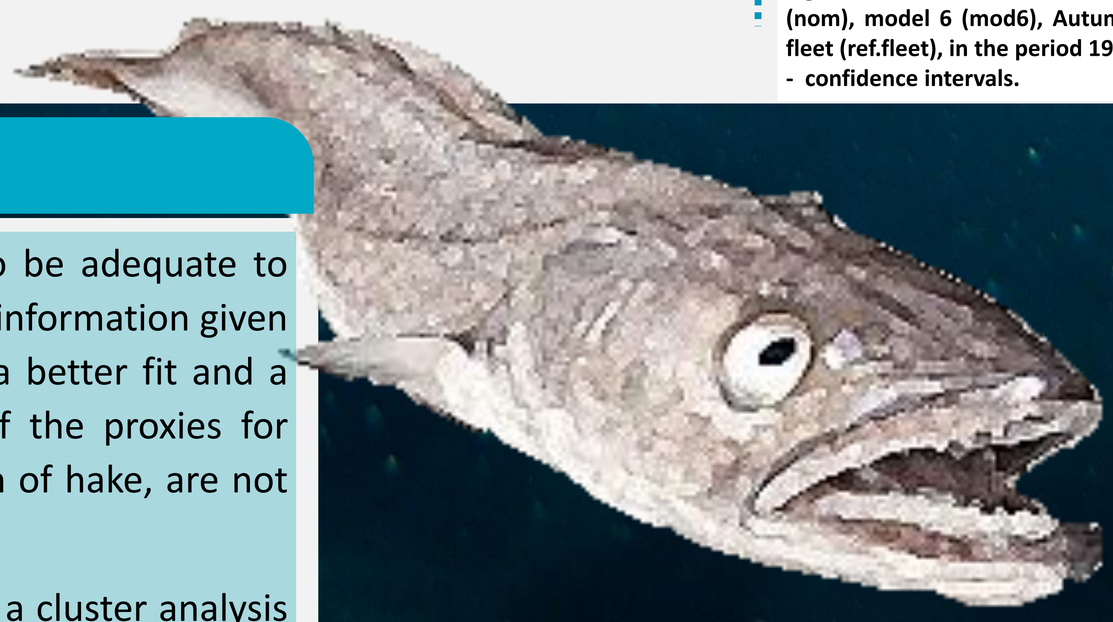


Figure 2. Standardized CPUEs of hake obtained from the nominal series (nom), model 6 (mod6), Autumn groundfish survey (IBTS) and reference fleet (ref.fleet), in the period 1989-2020. Shaded grey area and vertical lines - confidence intervals.

CONCLUSION

The GLM assuming a Tweedie distribution seems to be adequate to explain the hake CPUE trends also accounting for the information given by the zero-valued observations. Model 6 provides a better fit and a better correlation with IBTS index, though some of the proxies for target fishing, *e.g.* the total catch and the proportion of hake, are not truly independent from the response variable.

For future work, this model could be improved using a cluster analysis to identify clusters of target fishing.



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